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$$0 = c_m - (m+1) \frac{A_{m+1}}{(m+1)!}$$

$$\therefore c_m = (m+1) \frac{A_{m+1}}{(m+1)!} \text{ and } \phi(x) = \sum c_m x^m = A_1 + A_2 x + \frac{1}{2!} A_3 x^2 + \dots$$

$$+ \frac{1}{m!} A_{m+1} x^m.$$

$$\therefore \phi(x) = \frac{du}{u}. \quad \text{But } \phi(x) \equiv (1 - \frac{x^2}{2}) (1-x)^{-1}. u = \frac{u}{2} [1 + x + \frac{1}{1-x}].$$

$$\therefore \frac{du}{u} - \frac{dx}{2(1-x)} = (\frac{1}{2} + \frac{x}{2}) dx. \quad \text{Integrating, we obtain}$$

$$\log u + \frac{1}{2} \log(1-x) = \frac{x}{2} + \frac{x^2}{4} + c.$$

Now when  $x=0$ ,  $u=1$ , and hence  $c=0$ .

$$\therefore \log[u(1-x)^{\frac{1}{2}}] = \frac{x}{2} + \frac{x^2}{4}.$$

C. N. Schmall should have received credit for solving 317.

## MECHANICS.

357. Proposed by W. J. GREENSTREET, M. A., Stroud, England.

A portion of a circular cylinder cut off by two planes through the axis rests with its curved surface on two rough horizontal rails parallel to its axis, the coefficients of friction  $\mu_1, \mu_2$  at upper and lower rails respectively. If the body is in limiting equilibrium at both rails when the plane through the axis and the center of gravity is perpendicular to both rails, find the distance of the center of gravity in terms of the distance between the rails, the inclination of their plane to the horizon, and the coefficients of friction.

358. Proposed by W. J. GREENSTREET, M. A., Stroud, England.

Two heavy particles connected by a string, length  $l$ , lie one on each of two inclined planes with common horizontal edge and of angles  $\alpha$  and  $\beta$ . The inclination of the string to the edge varies as the inclination to the horizon of a simple pendulum of length  $l(\sin \alpha + \sin \beta)$ .

No solutions of these problems have been received.

259. Proposed by J. SCHEFFER, A. M., Hagerstown, Md.

A uniform beam of the weight  $W$ , rests on a horizontal plane, and leans against a vertical wall, but so as *not* to lie in a vertical plane. Denoting the pressure upon the horizontal and vertical planes, respectively, by  $x$

and  $y$ , the coefficients of friction respectively, by  $\mu$  and  $\mu'$ ; the angle which the perpendiculars from the foot of the beam upon the intersection of both planes makes with the beam by  $\phi$ ; the angle which this perpendicular makes with the direction of the friction peg by  $\xi$ ; and the angle, which the projection of the beam upon the vertical wall makes with the vertical line, by  $\psi$ . To prove:  $(1+\mu^2)\mu'^2\sin^4\phi - [1+\mu'^2+4\mu^2\mu'^2]\sin^2\psi + 4\mu^2\mu'^2 = 0$ ;  $\tan\xi = \mu'\cos\phi$ ,  $\tan\phi = \mu'\cot\psi$ ,  $x = \frac{\mu\cos\xi}{1+\mu\mu'\sin\psi\cos\xi}W$ ,  $y = \frac{1}{1+\mu\mu'\sin\psi\cos\xi}W$ .

Solution by S. G. BARTON, Ph. D., Swarthmore College.

Resolving the forces horizontally perpendicular to the line of intersection of the planes, and vertically, we have, respectively,

$$(1) \quad \begin{aligned} x\mu\cos\xi &= y \\ \text{and} \quad x + \mu y\sin\psi &= W. \end{aligned}$$

Solving these simultaneous equations for  $x$  and  $y$  we have

$$(2) \quad x = \frac{1}{1+\mu\mu'\sin\psi\cos\xi}W, \quad y = \frac{\mu\cos\xi}{1+\mu\mu'\sin\psi\cos\xi}W.$$

Resolving horizontally parallel to the line of intersection we have

$$y\mu'\cos\phi = x\mu\sin\xi,$$

which by use of (1) reduces to

$$(3) \quad \mu'\cos\phi = \tan\xi.$$

The beam, its projection upon the horizontal plane, and the line from the foot of the beam perpendicular to the line of intersection of the planes are three edges of a trihedral angle, one dihedral angle of which is a right angle, and the face angles  $\xi$ ,  $\phi$ , and  $\beta$ , where  $\beta$  represents the inclination of the beam to the horizon. Considering this trihedral angle as bounded by a sphere with its center at the vertex, we have, from spherical trigonometry,

$$(4) \quad \cos\beta = \cos\phi \sec\xi.$$

Considering the other end of the beam, the angle between the beam and its projection on the vertical plane is  $90^\circ - \phi$ , and that between the beam and the vertical line through its end is  $90^\circ - \beta$ . From this trihedral angle we find similarly

$$(5) \quad \sin\beta = \cos\psi \sin\phi.$$

Squaring and adding these relations to eliminate  $\beta$ , we find

$$1 = \sin^2 \phi \cos^2 \psi + \cos^2 \phi \sec^2 \xi,$$

and using (3) to reduce,

$$\begin{aligned} \sec^2 \phi &= \tan^2 \phi \cos^2 \psi + 1 + \mu'^2 \cos^2 \psi \\ \tan^2 \phi (1 - \cos^2 \psi) &= \mu'^2 \cos^2 \psi, \text{ or} \\ (6) \quad \tan \phi &= \mu' \cot \psi. \end{aligned}$$

Taking moments about the top of the beam in the vertical plane containing the beam, calling the length  $2L$ , we have,

$$\begin{aligned} 2L \cos \beta x - 2L \sin \beta \mu x - L \cos \beta W &= 0, \text{ or} \\ 2(1 - \mu \tan \beta)x - W &= 0; \end{aligned}$$

$$\text{or using (2),} \quad 1 - 2\mu \tan \beta - \mu \mu' \sin \psi \cos \xi = 0.$$

Dividing (5) by (4) and using (6), we find,  $\tan \beta = \frac{\mu' \cos^2 \psi}{\sin \psi} \cos \xi$ , which substituted, gives  $\sec \xi = \mu \mu' (2 \frac{\cos^2 \psi}{\sin \psi} + \sin \psi)$ , or by (3),

$$\sqrt{(\mu'^2 \cos^2 \psi + 1)} = \mu \mu' \left( \frac{2 - \sin^2 \psi}{\sin \psi} \right).$$

Squaring, we easily find

$$(1 + \mu^2) \mu'^2 \sin^4 \psi - (1 + \mu'^2 + 4\mu^2 \mu'^2) \sin^2 \psi + 4\mu^2 \mu'^2 = 0.$$

260. Proposed by W. J. GREENSTREET, M. A., Stroud, England.

To the ends of a fine inextensible string, length  $2l$ , are attached to equal, smooth, spherical, equally elastic ( $e$ ) particles. At first the middle point of the string touches a rigid, fixed, circular rim, radius  $a$ , and the particles are  $2l$  apart. They are now projected with equal velocities perpendicular to the string and curl around the rim. If  $l$  is greater than  $\pi a$ , find the condition that the particles will move after collision along tangents to the rim, the whole motion being on a smooth horizontal plane.

Solution by H. PRIME, Boston, Massachusetts.

Let  $P$  be the middle of the string,  $Q$  the point of impact,  $O$  the center of the rim,  $R$  the point of tangency with the string at the moment of impact and  $AB$  the normal through  $Q$ ;  $\theta$  and  $\phi$  the angles which the velocities make